Note on the Rochester Cyclotron

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THE 130-inch cyclotron has accelerated protons out to a radius of $58\frac{1}{2}''$ (approximately the $n=0.2$ point) or to an estimated energy of 240 Mev since the first of the year. Measurement of the C'' activity of a carbon-tipped probe indicates average currents of about $0.1\mu a$ at this radius and radio-autographs of the target show the beam to be about 1″ in height and well centered vertically on the probe. Eastman Kodak NTB plates placed along the probe show, among many proton recoil tracks, π^- and π^+ tracks.

About 15 kw of r-f power for the Dee is furnished by a grounded grid oscillator with feedback through the Dee. The natural frequency of the Dee is varied from 26 to 18 megacycles by a rotating condenser. The condenser which is in the Dee tank consists principally of a rotor of copper-plated, thin-toothed zircon disks mounted on a shaft parallel to the back edge of the Dee and a Dee stator which is on the back edge of the Dee. The magnetic drag of this rotor up to 2000 r.p,m. is small compared to the power taken by the rotor shaft seals. The copper-plated ceramic disks already give promise of satisfactory life.

Ion loading of the Dee is obviated by a negatively biased grid structure covering the linear above and below the Dee. Globar resistors break the grid into lengths too short to resonate to the Dee frequencies.

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Fluorescence of Anthracene Excited by High Energy Radiation*

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SINGLE crystals of anthracene were prepared by a method similar to that of P. R. Bell[1] and used for scintillation counters. At the suggestion of K. Lark-Horovitz, the spectra of the scintillations produced by high energy bombardment have been studied and compared with the fluorescence bands produced by ultraviolet excitation.

Spectrograms of the fluorescence excited by copper $K\alpha$-radiation, 10-Mev deuterons, and a 10-millicurie radium-beryllium source were made with a small Hilger quartz spectrographs using Eastman 103–0 plates. For the spectrum with x-ray excitation a crystal was mounted at the tube slit at an angle of about 45 degrees to the beam, and the visible fluorescence was focused by means of an aluminum mirror on the collimator lens of the spectrograph. A similar mounting was used for bombardment with the cyclotron beam. For the radium-beryllium exposure the crystal was fastened over the spectrograph slit with the radiation source in contact with it. No attempt was made to distinguish between the effects of neutrons and gamma-rays. A five-minute exposure to x-rays with a 0.1-millimeter slit was sufficient to bring out the bands found. A ten-minute exposure was used with the deuteron beam and twenty-four hours with radium-beryllium.

In each case three bands were observed between 4120 and 4720A with the most intense band at 4440A. No other bands were found between 2500 and 5000A. The wave-lengths of band intensity maxima were determined. The values found agree with those observed using ultraviolet excitation to the same extent as the ultraviolet values agree among themselves. Wave-length values in Table I, with the exception of the writer's, are for ultraviolet excitation.

To correlate the known bands with the counting properties,

Table I. Wave-lengths of intensity maxima for anthracene.

Data of	Intensity maxima in angstrom units							
Dowell[a]	—	—	4250	—	4490	—	4740	4980
Ganguly[b]	4030	—	4220	4380	4450	—	—	—
Ganguly[c]	4000	4140	—	4400	—	—	4680	—
Kortüm and Finkh[d]	4000	—	4200	4400	—	—	4700	4950
Obreimov[a]	—	4090	—	4340	—	4610	4750	4950
Pringsheim[e]	4025	—	4220	—	4450	—	4735	5090
Writer	—	—	4240	—	4440	—	4700	—

[a] Shishlovskii, Comptes Rendus 15, 29 (1937).
[b] S. C. Ganguly, Nature 153, 652 (1944).
[c] S. C. Ganguly, J. Chem. Phys. 13, 128 (1945).
[d] Kortüm and Finkh, Zeits. f. physik. Chemie B52, 263 (1942).
[e] P. Pringsheim, Trans. Faraday Soc. 35, 28 (1939).

counts were taken with a series of Wratten filters placed between the scintillating crystal and the 931-A photo-multiplier tube using a Co^{60} gamma-source at a constant distance from the crystal. Counts were taken at different pulse heights with and without each filter, and a graph of counts against discriminator setting was made. Since the discriminator setting fixes the minimum pulse voltage to be registered, it is proportional to the intensity of the weakest scintillations which are recorded. Thus it is possible to determine the transmittance for a given filter by determining the discriminator setting for a fixed number of counts with and without the filter.

No counts above background occurred when the fluorescence range was blocked by filters. For Wratten filter 2-A the transmittance found experimentally was 0.74. According to the manufacturer, the average transmittance of this filter between 4200 and 4700A is 0.78. The agreement is satisfactory; the slight difference may be due to the fact that the transparency of the filter drops rather sharply just below 4200A, whereas the fluorescence bands extend to about 4120A.

The above investigations again point to the fact that the fluorescence of anthracene is particularly suited to scintillation counting with a 931-A or 1P-21 photo-multiplier tube, which are most sensitive in the spectral range 3500–4500A.

* Research carried out during the summer of 1948, supported in part by the Office of Naval Research and Signal Corps.
[1] P. R. Bell, Phys. Rev. 73, 1405 (1948).

The β-Spectrum of H^3

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THE proportional counter technique previously described[1,2] has been used to study the β-spectrum of H^3 an investigation of which has recently been reported by Curran *et al.*[3]

The two counters *I* and *II* described in reference 2 were used. The fillings are given in Table I.

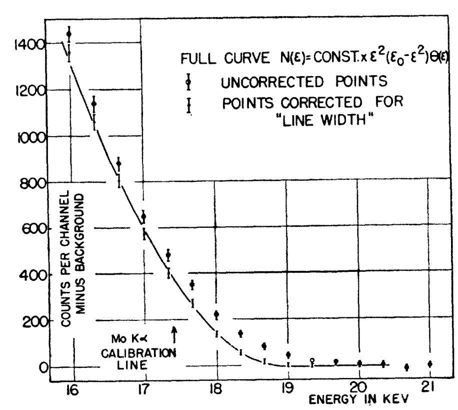

Fig. 1. The spectrum of H^3 in the region of the end

TABLE I. Counter fillings used.

	Counter *I*	Counter *II*
Xenon	50 cm Hg	26 cm Hg
Argon	—	14 cm Hg
Methane	10 cm Hg	10 cm Hg
Hydrogen	~1 cm Hg	~0.2 cm Hg
H^3	~7000 counts/min.	~30,000 counts/min.
A^{37}	—	~6000 counts/min.

Both counters were operated at gas multiplication factors of several thousand. The absolute energy scale was obtained by firing into the counter a beam of Mo $K\alpha$-x-rays (17.4 kev) from a crystal spectrometer. In counter *I* this beam was parallel to the counter wire, in *II* perpendicular to it. The assumption that these energy calibrations were representative of the properties of the counter as a whole was checked directly for counter *II* by measuring the Mo $K\alpha/A^{37}$ pulse size ratio,* and is inferred for counter *I* from the agreement between the end point energy determinations in the two counters.

The complete spectrum was investigated in counter *I*. Since counter linearity had to be maintained up to 20 kev, we were not able to use multiplication factors as high as those used in the investigation[4] of the Cl L_I peak (280 ev). Consequently the amplifier noise was apparent at energies as high as about 600 ev.

At the ends of the counter the multiplication falls off due to reduced field strength. Disintegrations occurring in this region will produce pulses of spuriously low amplitude. Clearly the shape of the spectrum is most affected at low energy. Due to lack of data the correction to be applied is uncertain, a fact which precludes a quantitative comparison of our results with Fermi's theory in the region near the most probable energy (~2.5 kev). However the results agree with the theory within the limits of the correction uncertainty (~10 percent at 1 kev).

Above 5 kev the correction is very small, and close agreement with the theory is obtained (wall effects are negligible). We have concentrated on this energy region, in particular we have used both counters for a careful investigation of the end point. Using a biased amplifier, the spectrum above 15 kev was expanded over the pulse analyzer. The results were compared with Fermi's theory, assuming a zero neutrino rest-mass. The theoretical distribution $N(\epsilon)$ can be written as constant $\times\epsilon^2(\epsilon_0-\epsilon)^2\theta(Z,\epsilon)$, where θ gives the Coulomb field effect.[5] In counter *I* the 17.4-kev calibration line was found to have a Gaussian shape of standard deviation $\sigma=700$ ev, over a range of at least $\pm 3\sigma$. In counter *II* σ was 1100 ev. The corrections to be applied for this line width were obtained by calculating the effect of a Gaussian spread on the theoretical distribution. A provisional value for the end point energy is adopted:** the corrected data are then used to redetermine the end point.

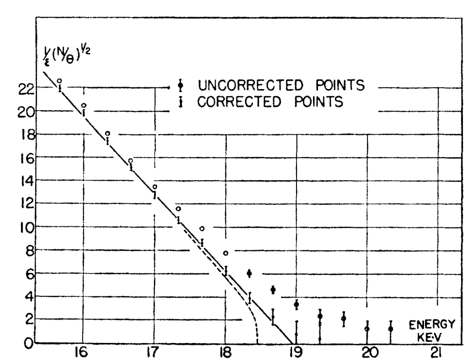

FIG. 2. "Kurie" plot of the end of the H^3 spectrum. The theoretical curve (shown dotted) corresponding to a finite neutrino mass of 500 ev (or 1 kev —see text) has been included for comparison.

A theoretical curve based on this new value is then used as before. The progress of successive approximations is extremely rapid.

Figures 1 and 2 show the experimental and corrected points obtained using counter *I*. The fact that the corrected points lie on the assumed theoretical curve from which the corrections were computed means that our initial assumption of a zero neutrino mass is correct, within our limits of error.

The dotted curve in Fig. 2 has been drawn to show the effect of a neutrino mass of 500 ev[6] (or 1 kev if a later modification[7] of the theory is accepted). If this distribution were used to correct for line width, a smaller correction would result and the discrepancy between the corrected data and the dotted curve would be even more marked than shown in Fig. 2. Nevertheless, in view of the width correction magnitude and the finite (300 ev) pulse analyzer channel width, we do not feel justified in definitely excluding a finite value of 500 ev (or 1 kev) for the neutrino mass.

Very similar results were obtained from the data of counter *II*: there is again no evidence for a neutrino mass greater than zero. The corrections for line width, however, are greater than for counter *I*.

The extrapolated end-point energy from the corrected data, is for counter *I*, 18.95, and for counter *II*, 18.9 kev. We believe that the true end point is at 18.9(5) kev within ±0.5 kev.

The first publication[3] of Curran *et al.* gave a value of 16.9 ±0.3 kev. This has recently[8] been increased to 17.9±0.3 kev. Calibration lines (Cu and Ni *K* x-rays) of energy about one-half of the end-point energy were used.

[1] D. H. W. Kirkwood, B. Pontecorvo, and G. C. Hanna, Phys. Rev. **74**, 497 (1948).
[2] G. C. Hanna, D. H. W. Kirkwood, and B. Pontecorvo, Phys. Rev. **75**, 985 (1949).
[3] S. C. Curran, J. Angus, and A. L. Cockcroft, Nature **162**, 302 (1948).

* A^{37} gives a 2.8-kev calibration line which is truly representative, since, as for H^3, the disintegrations occur uniformly throughout the counter volume.

[4] B. Pontecorvo, D. H. W. Kirkwood, and G. C. Hanna, Phys. Rev. **75**, 982 (1949).
[5] E. Bleuler and W. Zünti, Helv. Phys. Acta **19**, 375 (1946).

** Fortunately the correction is small for points lying more than 1.5σ away from the end point so that a fairly good value of the end point is available immediately from the extrapolation of a "Kurie" plot (Fig. 2) of uncorrected data. For example in counter *I* this value is greater by only 300 ev than the one finally derived.

[6] O. Kofoed-Hansen, Phys. Rev. **71**, 451 (1947).
[7] J. R. Pruett, Phys. Rev. **73**, 1219 (1948); C. S. Cook, M. L. Langer, and H. C. Price, Phys. Rev. **73**, 1395 (1948).
[8] S. C. Curran, J. Angus, and A. L. Cockroft, Phil. Mag. **40**, 53 (1949).

Ferromagnetic Alloys in the System Copper-Manganese-Indium

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IN a recent publication by Hames and Eppelsheimer on ferromagnetic manganese alloys,[1] reference was made to an article by S. Valentiner,[2] who has reported the existence of ferromagnetic alloys in the system Cu-Mn-In, with a maximum intensity of magnetization at the point Cu_2MnIn. We have been working on this same system, and since the journal containing Valentiner's report is not available as yet, we wish to report some of the results of our work.

About fifteen alloys have been prepared, most of them containing a constant atomic ratio of 2Cu:1Mn and with the indium content increasing from zero in steps of 5 atom percent to 60 atom percent, the latter being the most recent preparation. Except for the Cu-Mn binary alloys all of the specimens prepared were definitely ferromagnetic. No quantitative measurements of intensity of magnetization have yet been made; the Curie point of an alloy composed of copper, manganese, and indium in the approximate atomic ratio of 45:20:35 is about 250°C.